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STARNET: A MultiGbit/s Optical Local Area Network With Both Packet and Circuit Switching

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Introduction: The potential of passive star WDM networks is believed to be extremely high [1], [2], [3]. STARNET is a new broadband optical LAN based on such physical structure. Every STARNET node supports both packet traffic and a high-speed WDM circuit interconnect, simultaneously and independently. As a result, STARNET carries diverse types of traffic (i.e. bursty and continuous, low-speed and broadband) in an efficient way. Each node requires only two lasers and its structure permits frequency stabilization of the whole network. An experimental 4-node, 12Gbit/s (3Gbit/s per node), FDDI-compatible (at the packet network level) STARNET is being built at Stanford University.

Network structure: Each node of the network is optically connected to a passive optical star (**Fig. 1**). Each node is also equipped with a fixed frequency transmitter which is assigned a unique frequency, so that a comb of optical carriers is formed. Transmitters multiplex two independent data streams on the same optical carrier, the C ('circuit') stream and the P ('packet') stream, using non-interfering modulation formats, DPSK and low-modulation-index ASK, respectively.

Every node has two receivers: a tunable and a fixed one. The tunable receiver can be tuned to any other node. High-speed (3 Gbit/s) links can be established between nodes through the C streams and the tunable receivers. The broadband circuit interconnect is thus obtained.

The fixed receiver receives the P stream of the *previous node* in the frequency comb. Through this arrangement, a store-and-forward chain is set up among the nodes, and a logical loop is formed as shown in Fig. 2. The resulting logical topology is identical to FDDI and this standard has been chosen to implement the packet network part of STARNET.

The packet network and the circuit interconnect use different receivers and different modulation formats. Thus, they can operate simultaneously and independently.

Our node implementation solution makes use of only two lasers per node since part of the transmitter light is used as LO for the fixed receiver. Laser tuning is used to set up *circuit* connections and therefore does not need to be fast. The transmitter exploits a new $LiNbO_3$ combined phase-amplitude modulator. Both receivers employ coherent detection. The fixed receiver achieves visibility of the previous node in the frequency comb thanks to the use of a new frequency allocation technique of the node carriers [4]. Since the fixed receiver is permanently tuned to the previous node, frequency stabilization for the whole network is attained through relative frequency stabilization of each node with respect to the previous one.

The packet network carries low-to-medium speed data as well as network control information for the circuit interconnect. The circuit interconnect, which enables any node to connect to any other node at several Gb/s per link, also permits broadcasting and other connection arrangements which are especially suitable for video-conferencing and computer interconnections.

An experimental 4-node STARNET is currently being built at the Optical Communication Research Laboratory of Stanford University. The high speed links use DPSK modulation at 3 Gbit/s, for a total throughput of 12Gbit/s. The packet network makes use of FDDI boards. A multimedia workstation is connected to each node and the four workstations will ultimately share video, HD documents, sound and voice through the network.

With a transmitted power of 0 dBm and 3Gbit/s per node on the C link, the system power budget amounts to 51 dB. Allowing 5dB for excess loss at the star coupler and 16dB as system margin, STARNET could support a thousand nodes with a total throughput of 3 Tbit/s, given the availability of lasers tunable over a suitable range (approx. 100 nm).

Enhanced STARNET architectures: The packet network can be logically segmented into independent sub-rings (see Fig. 3). Packet exchange among subrings is achieved through an internal packet ring, which is established among network-dedicated nodes (one per subring). This arrangement uses more efficiently the transmission capacity of the packet network, and drastically cuts packet propagation delays. The assignement of a node to a subring can be dynamically changed. Each subring can hold tens to hundreds of nodes.

A further enhancement of STARNET permits to form a multihop broadband packet network among an arbitrary subset of the network nodes which enable STARNET to handle massive supercomputer data exchange in an optimal way.

In summary, STARNET is a new optical LAN based on a passive star topology. It supports both packetized traffic and high-speed WDM circuit interconnect on the same physical network. An experimental four-node, 12Gbit/s, packet-traffic-FDDI compatible STARNET is currently being built at Stanford University.

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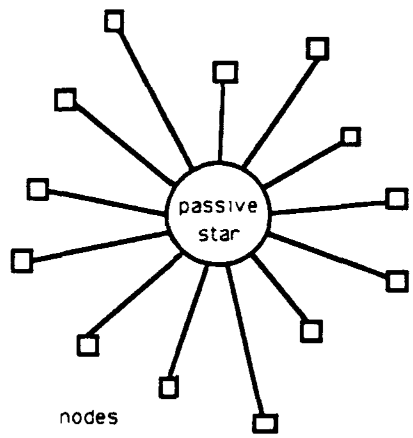

Figure 1: Each node is connected to every other node of the network through a passive star coupler.

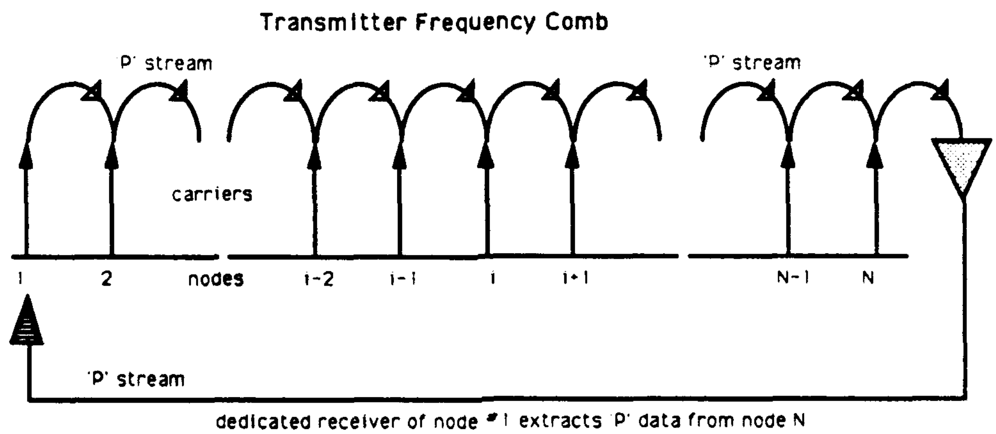

Figure 2: Comb of optical carriers, with logical connections among nodes for the packet network. The first node of the chain is equipped with a receiver capable of extracting the P stream of the last node in the comb, and relays data downstream.

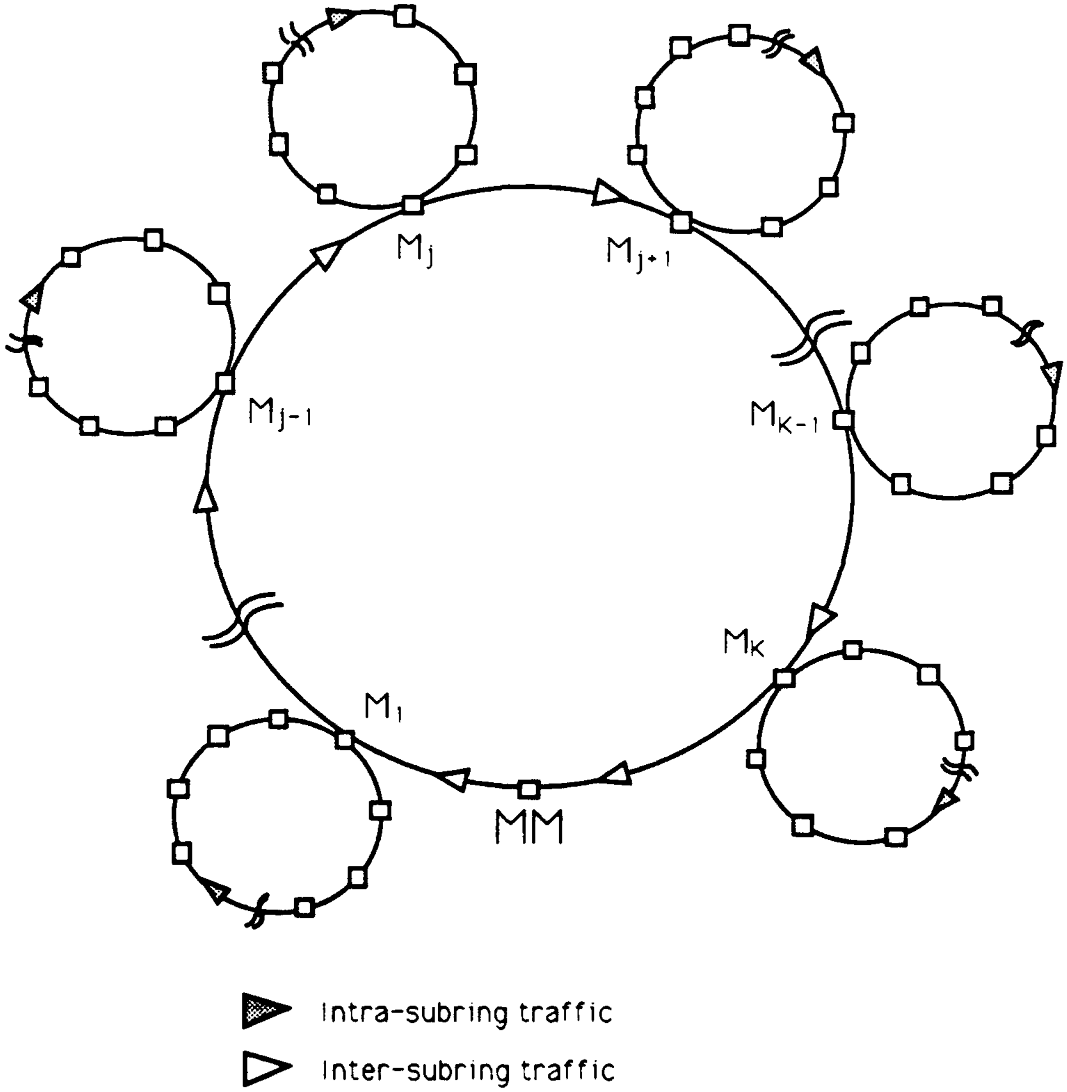

Figure 3: The packet network can be logically arranged like a ring of subrings; packets whose source and destination nodes are in the same subring do not enter the main ring, which is meant to transport packets between different subrings.